Science Activity: **Osmosis, Diffusion, & the Egg-citing Eggs-periment**

Introduction:

All living things are made up of cells responsible for every job our body does. To perform these jobs properly, cells need to bring in certain things from outside the cell – just like an individual person usually needs help from other people to do a big project. These things – or molecules – enter cells by passing through the cell membrane.

Living cells are surrounded by a membrane separating what's inside – water, nucleus, etc. – from what's outside – water, other cells, nutrients, etc. The cell membrane dictates what substances can and can't enter that cell.

Because cell membranes are selective, they prevent certain particles from entering by having holes only large enough to allow small particles to enter. Cell membranes are therefore called semi-permeable and only particles of a certain size are allowed to pass through.

This is easy to understand if you think of a basketball net. Only certain size balls get through – a basketball will go through the hoop, as will a tennis ball, but a big beach ball will not. Semi-permeable cell membranes work the same way. Particles like sugars and salts dissolved in water surrounding the cell might try to pass get in, but are too big to pass through the membrane, and therefore, do not get in.

The following activities demonstrate the concepts of cell biology, diffusion and osmosis and provide the basis for understanding how amphibians breathe and drink through their thin, semipermeable skins. But first, you'll need to review some basic vocabulary:

An **atom** is a unit of matter composed of a nucleus surrounded by electrons, and is the smallest unit of an element.

A **molecule** is composed of two or more atoms held together by chemical forces. It is the smallest particle of a substance that retains its chemical and physical properties.

Diffusion is the process by which molecules move from an area of higher concentration to an area of lower concentration.

Osmosis is the process by which water diffuses through a cell membrane.

A **permeable** material allows something to pass through it.

A **cell membrane** controls the movement of various substances in and out of the cell. When the rate of materials moving in and out is the same, it is in **equilibrium**.

A **selectively permeable membrane** allows some substances, like liquids or gases, to pass

through while others cannot. A **cell membrane** is an example of a semi-permeable membrane.

Circumference is the size of an object measured by the distance around it.

Amphibians and aquatic animals must adjust their internal chemistry in response to their surroundings. For example, aquatic animals take in the water, salt and other minerals necessary to sustain life through the process of osmosis. However, they must maintain an ***osmotic balance*** to prevent a toxic excess of minerals entering their bodies.

Diffusion and osmosis are important concepts for understanding amphibians. Unlike our water-proof skin, the thin, permeable skin of amphibians lets oxygen and water molecules to pass through which allows them to breathe and drink right through their skin!

Still feel like you need more information on diffusion & osmosis?

If so, read the next section, MORE BACKGROUND ON DIFFUSION AND OSMOSIS. If not, skip to Experiment #1 and get ready to amaze your students with these experiments!

More background info on diffusion & osmosis

1. Diffusion is a basic concept of molecular movement that helps explain how many living systems work.

Diffusion is especially important in understanding amphibians because they have permeable skins that allow for the passage of air and water. This explains how amphibians breathe and drink right through their skins! Diffusion tells us that molecules – combinations of atoms held together by chemical bonds – move from areas of high concentration to areas of low concentration. Molecules can move through air, liquid and in or out of living cells. All animal cells are surrounded by a cell membrane that governs which materials may move in an out of that cell. Cell membranes contain tiny holes that allow only molecules of a certain size to pass through. Cell membranes, therefore, are selectively permeable.

2. The diffusion of water molecules through a selectively permeable membrane is called osmosis.

A cell membrane is usually permeable to oxygen, water and carbon dioxide. Cell membranes are usually not permeable to larger molecules like sugars and salts.

3. A high concentration of water means there is nothing diluting it.

Diffusion tells us that molecules move from areas of high concentration to areas of low concentration, and osmosis describes how water diffuses through a cell membrane. Pure water is an example of a highly concentrated substance – there is very little diluting the water. An example of a substance with a low concentration is salt water – the water is diluted by salt.

4. When molecules are moving in and out of a cell at the same rate, the system is in equilibrium.

Experiment #1: Semi-Permeable Membranes

Materials:

1. 1/2 cup salt
2. 1/2 cup dry beans
3. jar with lid (quart or liter)
4. colander
5. large bowl

Procedure:

1. Pour salt and dry beans into jar.
2. Secure lid and shake back and forth several times to mix contents.
3. Hold colander over bowl while helper opens jar and pours out contents.
4. Gently shake colander up and down several times over bowl.
5. Observe contents of bowl and colander.

Explanation:

In this gear up demonstration, the colander acts as a semi-permeable cell membrane that allows only certain size particles to pass through to the bowl. In this example, the salt is small enough to pass through while the beans are not. In a cell, water, carbon dioxide, and oxygen are small enough to cross the membrane, but larger particles cannot cross.

Experiment #2: Diffusion & molecular movement

Materials:

1. 1 beaker or clear cup
2. 1/2 cup of water
3. 3-4 drops of food coloring
4. paper and pencil to record observations

Procedure:

1. Fill beaker 1/2 way with water.
2. Add 3-4 drops of food coloring and let jar sit – do not swirl!
3. Observe beaker for a few minutes.
4. Record what happens to the color of the water.

Explanation:

In this second gear-up demonstration, the food coloring diffuses throughout the water. When first dropped into the water, the part of the water that shows color has a high concentration of food coloring. Over time, the color begins to spread throughout the water to areas with no color – areas with low concentration of food coloring. Eventually, the color is evenly spread throughout the entire beaker of water, and the system reaches equilibrium. The same theory explains how the smell of perfume diffuses throughout a room, or how a tea bag steeps in water.

Experiment #2: Extension

To demonstrate that diffusion is not limited to water and to explain how molecules move through other media, like gas, try this experiment with your class.

Materials:

1. balloon
2. vanilla extract
3. shoe box

Procedure:

1. Before class, add one or two drops of extract into deflated balloon.
2. Blow balloon up. Tie it off and place it in a shoe box.
3. Tape lid tight with masking tape.
4. During class, ask students to open one end of the lid and smell contents.
5. Show students box contents and instruct them to draw a picture and record observations and explanations, using appropriate vocabulary – for example, why does the box smell like vanilla extract when it was put only in the balloon?

Explanation:

In this experiment, the box smelled of vanilla extract, even though it was placed only inside the balloon, because of diffusion. The vapors, or gas scent molecules passed through the skin of the balloon, from an area of high concentration to an area of low concentration. The skin of the balloon acts like a selectively permeable cell membrane, allowing only vapor molecules to pass through. Liquid scent molecules are too large to pass through the skin, and remain inside.

Experiment #3: The Egg-cellent Eggs-periment

In this experiment, each student or group of students will use a raw egg to explore how osmosis and diffusion allow molecules to pass through selectively permeable cell membranes. But first, the eggshell must be removed to expose the membrane. Simple white vinegar does this well – an acid, vinegar reacts with calcium carbonate in the shell to remove it. Bubbles that form when the egg is dropped in vinegar are evidence of this reaction.

Once the shell is removed, diffusion and osmosis are illustrated by exposing the egg to certain substances. Transfer the egg from the beaker with vinegar to a beaker containing a highly concentrated solution like molasses or saltwater, and after 24 hours, the egg will shrink because the water inside it wants to move outside – from an area of high concentration to an area of lower concentration. And this will cause the egg to shrink. Now put the egg into a new beaker containing water. Here, the egg will swell up because there is a higher concentration of water outside the egg than inside. The new size will be even bigger than the original size! And, as we learned in the first experiment, the reason only water diffuses across the membrane while the sugar in the molasses or the salt in the saltwater does not, is that sugar and salt particles are too big to cross the membrane.

In this experiment, the egg mimics an animal cell, and illustrates these properties of diffusion and osmosis:

1. If the concentration of water outside the cell is the same as the concentration outside, the amount of water moving across the cell membrane is equal to the amount coming out, and it will stay the same size. The system is in equilibrium.
2. If the water outside the cell contains more salt or sugar than the water inside – if it is less concentrated for water, in other words – water will move out of the cell from an area of high concentration to an area of lower concentration, and the cell will shrink.
3. If the water outside the cell contains less salt or sugar than the water inside – if it is more concentrated for water, in other words – water will move into the cell from an area of high concentration to an area of lower concentration, and the cell will swell.

Now you are ready to begin!

Objectives:

1. Students will understand the function of a semi-permeable cell membrane.
2. Students will understand how osmosis and diffusion allow particles to move in and out of cells, by passing through selectively permeable cell membranes.
3. Students will record careful and detailed observations of a scientific experiment.
4. Students will understand how osmosis and diffusion relate to amphibians.

Materials:

Each student or group of students should have the following:

1. one raw egg
2. three 250 ml beakers or big clear cups
3. 250 ml vinegar
4. 250 ml molasses
5. 250 ml saltwater
6. approximately 250 ml water
7. 12" piece of string and ruler
8. data sheet (included)
9. paper and pencil to record observations

Procedure:

1. Fill beaker almost to the top with vinegar.
2. Gently place egg into a beaker. Be careful not to drop egg!
3. Record observations – what do you notice?
4. Record predictions – what do you think will happen?
5. Place beakers in a refrigerator, or just aside for 24 hours and redistribute.
6. Record observations again – how does the egg look and feel? The egg shell should now be removed.
7. Gently rinse eggs and measure circumference by wrapping string gently around the middle of the egg. Hold your finger on the spot where the end of the string meets the rest of the string. Measure the distance between the end of the string and your finger with the ruler. Record measurement on data sheet.
8. Transfer egg to new beaker filled almost to the top with molasses or saltwater.

9. Record the properties of the syrup or saltwater – what does it feel and pour like?
10. Place beakers in refrigerator or just set aside for 24 hours and redistribute.
11. Record observations – has the syrup or saltwater changed any and how does the egg look and feel? Compare these observations to ones made earlier.
12. Gently take egg out of beaker and rinse off. Measure circumference using string and ruler. Record measurement on data sheet.
13. Transfer egg into new beaker filled almost to the top with water.
14. Place beakers in refrigerator or just set aside for 24 hours and redistribute.
15. Record observations again – how does the egg look and feel now?
16. Gently take egg out of beaker and measure circumference one last time. Record measurement on data sheet.

Assessment:

1. Students can define vocabulary words listed on Vocabulary Worksheet.
2. Students complete Data Sheets, record observations and conclusions.
3. Students complete Discussion Questions and share ideas with the class.

Extensions:

1. Have students design their own experiment by thinking of a different substance to put the egg into. Water with food coloring or cola work well. Ask them to develop their own hypothesis, record observations, compare results of new experiment with those of original experiment, and draw conclusions.

2. Ask students to weigh eggs in addition to measuring circumference.

3. Share the life history of a Paramecium. Because this organism lives in fresh water, surely there is a higher concentration of water molecules outside the cell then inside. Therefore, water diffuses across the membrane into the Paramecium. Ask students what this means for this organism.
The Paramecium would flood itself if it didn't have some way to get rid of all the water rushing in. Luckily, this organism has adapted by accumulating excess water accumulates in its "vacuole," a part of its body designed to expel water back into the environment.

National Science Education Standards:

Content Standard A:

- Develop abilities necessary to do scientific inquiry.

Content Standard C:

- Develop an understanding of structure and function in living systems.

Alaska Content Standards:

Science A(1)
Science C(3)

Juneau School District Core Content:

Science

Life and Human biology (6th-8th):

Forces and Motion: How do forces cause and affect motion?

- Describe the different methods of movement in living organisms (diffusion, osmosis)

References:

Egg-cellent Ideas for Osmosis and Diffusion. Remshak, Sue. The Science Spot. 16 March 2004 <http://sciencespot.net/Pages/classbio.html#Anchor-eggs>.

The Egg-Citing Eggsperiment. D'Asselandro, Liane & Smith Arthurea. Knight Foundation Summer Institute. 16 March 2004 <http://www.haverford.edu/educ/knight-booklet/theegg.htm>.

Vocabulary Worksheet

Please define the following terms:

1. molecule

2. diffusion

3. osmosis

4. permeable

5. selectively permeable

6. cell membrane

7. circumference

Discussion Questions

1. Why was the shell removed first?

2. How did the molasses or saltwater change? Can you explain why this change occurred?

3. How did the egg change from the beginning of the experiment to the middle, and then to the end. Use appropriate vocabulary in your explanation.

4. What do you think would happen if the egg was placed in orange juice instead of molasses? Why?

5. How does this experiment help explain how amphibians breathe and drink through their semi-permeable skin? How does it help explain why more amphibians do not live in saltwater?

EGG-CELLENT EGGS-PERIMENT

Data Sheet

	DAY 1	DAY 2	DAY 3	DAY 4
CIRCUMFERENCE				
OBSERVATIONS What is in the beaker today? Water, molasses or saltwater? What does your egg look and feel like today?				
PREDICTIONS What do you think will happen to your egg next?				